IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Appl. No.: 10/757,705 Confirmation No. 4474

Applicant: John C. Miller et al.

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Docket No.: 5118.05.01
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Declaration of John C. Miller under 37 CFR 1.132

I, John C. Miller, the undersigned, declare as follows:

1. I am one of the co-inventors of the present invention, namely the invention described and claimed in the above-captioned application.

2. I have read, and I understand, the above-captioned application.

3. I hold a Ph.D. degree in chemistry, which was received in about 1982 or 1983 from the University of Illinois, Chicago.

4. I have read, and I understand, U.S. Patent No. 5,885,912, inventor Thomas H. Bumbarger, issued March 23, 1999, which is referred to herein the "Bumbarger."

5. Bumbarger discloses a multiple-layered composite which, in relevant part, is (a) fashioned into garments and blankets which are (b) put on or placed over the user to cool or protect the user from heat. See for example Bumbarger at col. 1, lines 34-44.

6. The composite of Bumbarger has an outer retainer layer, a filler layer, an inner 'conductive' layer and, if used in the vicinity of fire, either a fire-resistant layer or a fire

retardant coating must be provided on the outside. See Bumbarger at col. 5, lines 26-33, col. 6, lines 46-50, and col. 8, lines 24-32.

7. The filler layer of Bumbarger is a fiberfill batting with tiny absorbent particles, such as superabsorbent particles, distributed throughout the fiberfill batting. See Bumbarger at col. 2, lines 8-10, and at col. 4, line 65, to col. 5, line 4.

Section A – Bumbarger's Insulator vs. Present Invention's Conductor

8. Fiberfill is a synthetic fiber, commonly polyester, used as filling and insulation, as in comforters, pillows, and outerwear. See the definitions of fiberfill attached as Group Exhibit 1. Batting is a layer of insulation in the form of wadded fiber sheets for stuffing furniture, mattresses and quilts. See the definitions of batting which are attached as Group Exhibit 2.

9. Bumbarger's fiberfill-batting exemplification, namely "DuPont "ARMADA" E. 89" (at col. 6, lines 41-42), provides no additional information regarding its fiberfill batting because DuPont has no "ARMADA" brand products and no "ARMADA" brand batting products of any company were located in Internet searches. See the DuPont brand list of Exhibit 3.

10. Bumbarger does not explicitly disclose the ratio of fiberfill batting to dispersed absorbent particles in its filler layer, but does disclose that the fiberfill batting is typically unaffected by the liquid utilized (at col. 4, lines 65-65). This is rather self-evident, because synthetic fibers, particularly those of the type used for fiberfill batting, such as polyester, are not affected by water.

11. Bumbarger states that, when soaked, a garment made of its composite provides effective body protection against intense heat in multiple ways, including that the filler-

layer water provides an effective thermal insulator between the retainer layer and the conductive layer. See Bumbarger at col. 6, lines 2-13. This statement, however, is somewhat imprecise because water is a thermal conductor, not a thermal insulator (which is discussed below) and Bumbarger's filler layer is neither water nor a continuous matrix of hydrated superabsorbent polymer (such as the present invention) but instead is a discontinuous matrix of fiberfill batting and hydrated superabsorbent polymer. As set out in the paragraph above, Bumbarger's absorbent particles are dispersed in fiberfill batting, and the fiberfill batting is unaffected when the particles are hydrated with water.

12. Again, fiberfill batting is an insulator. See Group Exhibits 1 and 2. Attached hereto as Exhibit 4 is a section on thermal conduction from a standard physics textbook. As seen in Table 23-3 of Exhibit 4, at exhibit page 6, water is a thermal conductor and has a thermal conductivity K of 0.0014 (kcal-m/sec-m^2-C^o), and moderate insulators, such as cork and glass wool, each have a thermal conductivity of 0.00001 (kcal-m/sec-m^2-C^o).

13. As seen in equation [23-8] of Exhibit 4, at exhibit page 5, the relative rates of heat transfer through different materials, and combinations of materials, under standard conditions in which the area, length and temperature differential are constants, can be simply calculated from the thermal conductivities, which permits the simple ballpark comparisons of heat transfer rates set out below.

14. Assuming that the thermal conductivity of a continuous matrix of hydrated superabsorbent polymer is about that of water, and that the thermal conductivity of Bumbarger's fiberfill batting is about that of cork and glass wool, I determined by simple calculations that, under standard conditions in which the area, length and temperature

differentials are constants, the heat transfer rates through a barrier of the present invention when filled with (a) 25%, (b) 50%, (c) 75% and (d) 100% by volume fiberfill batting, the balance being hydrated superabsorbent, in comparison to 100% hydrated superabsorbent polymer. In terms of how many times faster heat transfer is through 100% hydrated superabsorbent polymer, the results are: for (a), 36 times faster; for (b), 70.5 times faster; for (c), 105 times faster; and for (d), 140 times faster. A copy of the mathematical calculations are attached as Exhibit 5.

15. The calculated results shown in the paragraph immediately above strikingly demonstrate the insulation impact of the fiberfill batting in Bumbarger's filler layer. The fiberfill batting converts an otherwise thermal-conducting hydrated-superabsorbent matrix into a thermal insulator, and this is consistent with Bumbarger's claim that its filler layer is a thermal insulator.

16. In the systems and methods of claims 7-9, 48 and 51, and as explicitly described and illustrated in the present application, both the outer and inner surfaces of the barrier are water permeable, and the fast heat transfer between surfaces creates a steam layer on both sides, doubly protecting the fuel adjacent the inner surface.

17. The present invention's fast heat transfer also boosts the heat-buffering property of the barrier, even in broad embodiments where only the outer surface is required to be water permeable (pending claims except 7-9, 48 and 51), whereby the barrier maintains a temperature no higher than the boiling point of water throughout, from outside to inside.

18. As established above, the present invention's fast heat transfer is not, and cannot, be realized in Bumbarger's thermal-insulating discontinuous matrix of fiberfill batting and hydrated superabsorbent.

Section B – Bumbarger's Evaporation vs. Present Invention's Steaming

19. A layer of steam forms on the surface of a barrier of the present invention, which is discussed in more detail below. A vapor is formed in or about the composite of the Bumbarger '912 patent, but that vapor is not steam. Neither the "steam" word nor a steam actuality/expectation is found in Bumbarger, as discussed below.

20. Steam is the gas emitted from boiling water or evaporation of water at its boiling temperature. Water boils at 212 ^{o}F. Normal body temperature is 98.6 ^{o}F. Obviously Bumbarger's filler layer is not boiling when there is only the breathable water-proof conductive layer 16 between it and the user's body. The perspiration absorption discussed in Bumbarger patent would be of no concern in such scenario because the user could not survive.

21. Bumbarger says that as its retainer layer is exposed to heat, the liquid within the filler layer begins to vaporize and pass slowly through the retainer layer, creating a moist film on the outer surface of the retainer layer. See Bumbarger at col. 6, lines 14-17. Although the word "vaporize" can mean either evaporation or boiling, evaporation and boiling are not the same or equivalent phenomena. It is clear from the context of Bumbarger that by "vaporize" it means evaporation, not boiling.

22. A steam layer forms on the surface of a fire-retardant barrier of the present invention (all system claims and method claims 17, 49-51) and acts as a fire extinguisher, preventing ignition of the outer fabric by displacing oxygen at its surface, and therefore a person covered by the barrier would not be protected as disclosed in Bumbarger, but instead would be smothered from lack of oxygen.

23. When the steam layer forms on the surface of a fire-retardant barrier of the present invention in use, the absorbed water inside the barrier is kept at its boiling point, namely 100 ^{o}C. or 212 ^{o}F., and therefore a person (whose normal body temperature is 98.6 ^{o}F) covered by, or clad in, the barrier would be neither cooled nor protected as disclosed in Bumbarger. Such a clad or covered person would not survive.

24. When the steam layer forms on the surface of a fire-retardant barrier of the present invention in use, it prevents ignition of the outer fabric, and therefore the fire-resistance (non-flammability) required for the composite of Bumbarger would be at best redundant, and quite possibly obstructive.

Section C – Bumbarger vs. Wildfire Fighting Needs

25. Nothing in Bumbarger suggests using its composite in the method of the present invention, namely as a fire retardant barrier interposed between a fire and fuel, generating a fire-retardant layer of steam to preclude combustion of the fuel, and this inescapable observation is corroborated by the continuing void in wildfire-fighting techniques, despite the recognized and colossal need in that field, although Bumbarger issued more than seven years ago (in March of 1999).

26. It is common knowledge that wildfires not only scorch acres of land by the hundreds of thousands, and destroy homes by the thousands, they are deadly.

27. As reported in the media just weeks ago, wildfires in the southern plains of the U.S. caused almost a dozen fatalities and necessitated the evacuation of 1,900 people as the flames 'raced across more the 1,000 square miles' while the resolute fight against the fires 'from the ground and from the air' consisted of dousing rooftops with water and

dumping retardant for airtankers. See "Wildfires Kill 11 Across the Southern Plains", articles.news.aol.com, 3/14/2006, attached hereto as Exhibit 6.

28. In my home-state of California, 7.8 million acres are developed with housing unit densities meeting the Wildland-Urban Interface criteria and 70 percent thereof (about 5.5 million acres) are at significant risk (very high or extreme risk) to damage from fire. See "Synopsis - Wildfire Risks to Assets" from "The Changing California, Forest and Range 2003 Assessment", frap.cdf.ca.gov/assessment2003, October, 2003, attached hereto as Exhibit 7.

29. The same government report informs that, in ten bioregions in California, 3,165,000 housing units, or 26% of the total housing units, are exposed to significant fire risk, which figures include 79% of all housing units in the Sierra bioregion and 30% of all housing units in the Bay Area/Delta bioregion. See "Proportions of Housing Units in the Wildland Urban Interface at Significant Risk from Fire" from "The Changing California, Forest and Range 2003 Assessment", frap.cdf.ca.gov/assessment2003, October, 2003, pages 100-103, attached hereto as Exhibit 8.

30. The fatalities and devastation from recent fires in and around San Diego, California are common knowledge, and the media reported the toll at 25 fatalities, more than 3,600 homes and property damage topping $3.5 billion. See "Risk doesn't deter growth in fire-prone areas", 2004, by Dan MacMedan, USA TODAY, usatoday.com/news/nation/2004-02-03-fire-risk-usat_x.htm, at page 1, attached hereto as Exhibit 9.

31. California is not the only at-risk state, and the same article reports that 80% of all housing units in New Mexico and Wyoming, and 40% to 55% of housing units in other

Western states, including California, Washington and Oregon, are on land with fire potential. See Exhibit 9 at page 2.

32. As a homeowner in California, I am personally acutely aware of the residential restrictions mandated by the state, and backed-up by requirements of insurers, including defensible-space vegetation/flammable-material clearances around residences and fire-retardant roofing materials. See "Public Resources Code 4291" 2006, State of California, "Make Your Home Fire Safe", www.fire.ca.gov, May 2005, "100' Defensible Space Update", www.fire.ca.gov, Feb. 21, 2006, and "State Mandated Roofing Requirements, California Health & Safety Code", Committee for Firesafe Dwellings, attached hereto as Group Exhibit 10.

33. In summary regarding Exhibits 6 to 10, the fire risk to housing units, many of which are very expensive housing units, is extensive, extreme, very well recognized and long-standing, and the resolute fight against the fires 'from the ground and from the air' still consists of dousing rooftops with water and dumping retardant from air-tankers without any adoption of the body-cooling and body-protection composite articles of Bumbarger patent which issued in March of 1999, or any method commensurate to that of the present invention.

Section D – Bumbarger vs. Present System and Method Claims

34. A fire requires three components, namely fuel, oxygen, and heat energy sufficient to ignite the fuel (ignition heat). If any one of these components is removed, a fire will not burn. The barrier of the present invention isolates fuel not just from one of these components, but instead from two of these components, namely from the ignition heat (flames) and from oxygen. See present application at ¶ 23 (¶ 12 of filed application).

35. When a fire reaches a barrier of the present invention, the water absorbed in barrier forms steam. As the steam is formed, the temperature of the flames is lowered, thus reducing the heat available to propagate the fire. Additionally, the temperature of barrier will not exceed the boiling point of water until all of the water is evaporated, so that barrier cannot reach a temperature that is high enough for ignition. See present application at ¶ 25 (¶ 14 of filed application), system claims, method claims 17, 49-51.

36. In addition to precluding temperatures high enough for ignition, the steam formed by volatilizing the water absorbed in barrier creates a steam layer at the outer surface of barrier which acts as a fire extinguisher by depriving the fire of oxygen at the surface of barrier, thus quenching any flames that attempt to form at the surface. The steam layer is continually replenished during a fire because the water absorbed by superabsorbent polymer continuously forms steam until the water is exhausted. See present application at ¶ 26 (¶ 15 of filed application).

37. In addition, the steam layer not only helps to retard the protected fuel from burning, it also self-protects the barrier from burning. See present application at ¶ 26.

38. Bumbarger teaches that its composite, if used in the vicinity of a fire, must be protected with a separate fire-resistant layer outside of its retainer layer, or at least a fire-retardant coating on the retainer layer. See Bumbarger at col. 5, lines 26-20 and lines 30-33, and col. 6, lines 46-50.

39. In the absence of the disclosures of the present invention, and in the presence of the disclosures of Bumbarger noted immediately above, there is no motivation or impetus to interpose its composite as a self-protected barrier between fuel and flames. To the contrary, Bumbarger explicitly teaches that its composite itself must be protected when in

the vicinity of fire. It is only the disclosures of the present invention that hypothetically might suggest otherwise.

Section E – Video-Taped Test Establishing Striking Fire Protection and Barrier Self-Protection – Claims 1-2, 4-9, 14-18, 44-46 and 48-51.

40. Attached hereto as Exhibit 11 is a chronological series of screen-shot photographs of a video recording of a striking demonstration of the efficacy of the present invention. The video tape cassette was first itself photographed (photograph # 1) and then placed in a conventional home VCR and played. During playback of this video, photographs of the television screen were taken at intervals. The time-display feature of the camera was turned on to provide a record of the time lapses between the photographs, which are numbered from 2 to 52 for reference purposes.

41. Submitted herewith as Exhibit 12 is the tape cassette of the entire video recording, which has a playing time of about 60 minutes. When the demonstration was filmed, as seen on the Exhibit 12 video, the filming was only intermittent during the set-up prior to ignition of the straw pile shown therein, and after such ignition, about 52 minutes of the approximately 90 minutes of total burning time was filmed.

42. In the test recorded in Exhibits 11 and 12, thirty-six wood blocks, each measuring about 2 inches wide, about 2 inches tall and about 6 inches long, were set up as two identical stacks of 18 blocks. Each stack had three layers of blocks, and each layer had six blocks arranged in identical grids with small air spaces in between, as shown in Exhibit 11 photographs # 2 and # 3.

43. Two small barriers of the present invention were used to cover one of the two stacks. As seen in Exhibit 11 photographs # 3 and # 46-49, each barrier is about 24

inches by about 22.5 inches, and each has fifty-four pockets that are about 4-by-2.5 inches. Both barriers were made of cotton muslin fabric sewed together with stitches. Each pocket was loaded with about one gram of superabsorbent polyacrylamide polymer as, approximately, 0.25 mm diameter spherical particles.

44. As seen in Exhibit 11 photographs # 4-7, I first placed the dry barriers over the right-hand stack to show their coverage, then soaked the barriers in two containers of water until the pockets expanded to tautness, and then replaced the hydrated barriers over the right-hand stack.

45. In more detailed explanation, when the barriers expanded to tautness, they were expanded to their maximum volumetric capacity, and in reference to the barrier device itself they were fully hydrated. Each barrier weighed about about five pounds, and had a water loading of approximately 1.2 lb. water per square foot of surface area.

46. As seen in Exhibit 11 photographs # 6 and # 7, I placed the soaked barriers over the right-hand stack of wood blocks, one barrier overlapping a portion of the other, and I left the left-hand stack of wood blocks unprotected.

47. As seen in Exhibit 11 photographs # 8-9, I then blanketed the stacks with dry straw. I used two 75-pound bales of straw and spread the straw pile so that it not only covered each of the stacks, but also filled the space between the stacks and extended beyond the stacks, as seen.

48. As seen in Exhibit 11 photographs # 11-17, I then stuffed some paper around the edges of the straw pile and lit the papers with a cigarette lighter to ignite the straw, and the straw pile ignited.

49. As seen in Exhibit 11 photographs # 18-42, the pile of straw initially burns the same on both sides and in the middle, and then, after about 15-20 minutes of elapsed time on the video after ignition, the right-hand side of straw pile becomes essentially burned-out, while burning continues on the left-hand side.

50. As seen in Exhibit 11 photographs # 36-42, the straw pile itself is essentially burned out, and the continuing fire on the left-hand side is the burning of the left-hand stack of blocks. Actual flames from the stack can be seen licking through the burnt straw that remains on top of it.

51. As seen in Exhibit 11 photographs # 43-45 and # 50-52, after about 52 minutes elapsed video time after ignition of the straw pile, I removed the burnt straw from both stacks, removed the barriers from the right-hand stack and found that the left-hand stack of wooden blocks was completely burned (seen in photographs # 43 and 50-52), with nothing remaining except embers and ash, while on the right-hand side stack was undamaged (seen in photographs # 45 and 52).

52. As seen in Exhibit 11 photographs # 46-49, after I lifted the barriers off the right-hand stack, I held them up and turned them around, displaying each on both sides to demonstrate that both were intact, hydrated and essentially unburned. There were only a few cosmetic scorch marks on the outer fabric.

53. As strikingly seen in Exhibit 11 photographs # 50-52, the right-hand stack of wooden blocks was completely undamaged and even the grass on the ground immediately around it was unburned and still green, while there was nothing left of the left-hand stack except smoldering ash and embers, and the grass around it was charred and blackened.

Section F – Striking Fire Retardation in view of Drastic Need

54. The above-described test, which is shown in the Exhibit 11 photographs and Exhibit 12 video, corroborates other tests I have conducted and convincingly establishes that the present invention provides a solution for the well recognized and long-standing need to reduce or eliminate the fire risk to housing units which I describe above. The present invention provides a weapon for the resolute fight against the fires 'from the ground and from the air' which is far more effective than the current dousing of rooftops with water and dumping retardant from air-tankers. Commercialization of the barrier and/or the method of the present invention by me or my co-inventor is not, however, anticipated unless and until meaningful patent protection is secured, because the required financial investment would be at a great risk unless we secure serious patent protection.

55. I make this Declaration in its entirety based upon my personal knowledge.

I declare under penalty of perjury that the foregoing is true and correct.

Date: April 25, 2006

John C. Miller, Ph.D.
Fresno, California

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On this page: Dictionary

fiberfill

Dictionary

The American Heritage® dic·tion·ar·ies

fi·ber·fill (fī'bər-fĭl')

n.

Lightweight synthetic fiber used as filling or insulation, as in comforters, pillows, and outerwear.

Exhibit 1
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Merriam-Webster Online Dictionary

Thesaurus

fiberfill

One entry found for **fiberfill**.

Main Entry: **fi·ber·fill**
Variant(s): *also* **fi·bre·fill** /-"fil/
Function: *noun*
: synthetic fibers used as a filling material (as for cushions)

For More Information on "fiberfill" go to Britannica.com
Get the Top 10 Search Results for "fiberfill"

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Exhibit 1
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Dictionary

fiberfill

fiberfill

fi·ber·fill [fíbər fìl]

noun

Definitions:

synthetic stuffing material: synthetic stuffing or insulating material. Use: cushions, comforters, clothing.

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Exhibit 1
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Batting

From Wikipedia, the free encyclopedia
You have new messages (last change).

Batting has several meanings:

- In baseball, **batting** is the act of attempting to hit the ball thrown by the pitcher, in order to score runs. See Batting (baseball)
- In cricket, **batting** is the act of defending one's wicket with the cricket bat while attempting to score runs. See Batting (cricket).
- In quilting, **batting** is a layer of insulation between a top layer of patchwork and a layer of backing material. See Patchwork quilt.

*Look up **batting** in Wiktionary, the free dictionary.*

Retrieved from "http://en.wikipedia.org/wiki/Batting"

Category: Disambiguation

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Exhibit 2
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Settings

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Dictionary Thesaurus

bat·ting (băt'ĭng)

Synonyms
blink
nictate
nictitate
twinkle
wink

[Sense 2, from the beating of raw cotton to clean it.]

noun

1. The act of one who bats.
2. Cotton, wool, or synthetic fiber wadded into rolls or sheets, used for stuffing furniture and mattresses and for lining quilts.

bat[1] (băt)

[Middle English, perhaps partly of Celtic origin, and partly from Old French *batte*, pounding implement, flail (from *batre*, to beat; see batter[1]).]

noun

1. A stout wooden stick; a cudgel.
2. A blow, such as one delivered with a stick.
3. *Baseball* A rounded, often wooden club, wider and heavier at the hitting end and tapering at the handle, used to strike the ball.
4. *Sports*
   a. A club used in cricket, having a broad, flat-surfaced hitting end and a distinct, narrow handle.
   b. The racket used in various games, such as table tennis or racquets.

verb: bat·ted, bat·ting, bats.

transitive verb

1. To hit with or as if with a bat.
2. *Baseball*
   a. To cause (a run) to be scored while at bat: *batted the winning run in with a double.*
   b. To have (a certain percentage) as a batting average.
3. *Informal* To discuss or consider at length: *bat an idea around.*

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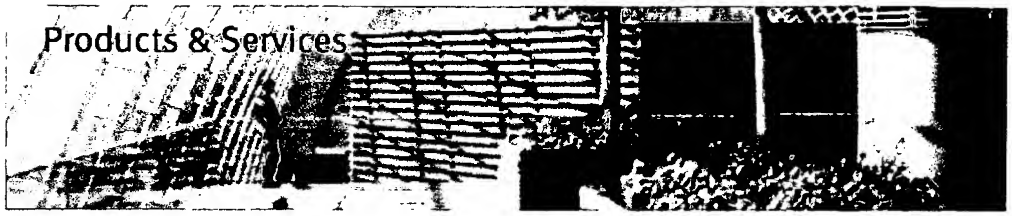
Exhibit 2
page 2 of 2

Select Product Family

- Select -

»



DuPont Home « Brands & Trademarks « A

Browse all Brands & Trademarks by:
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Brands & Trademarks A-Z

A

Accent® herbicide
Provides selective postemergence grass and broadleaf weed control in field corn. » More

Acturel™ medical fabric
Medical gown fabric that It provides a breathable, impervious barrier that's smart—it adjusts to your body temperature over time to maximize your comfort. » More

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For control of imported fire ants on lawns, recreational areas, golf courses and other noncrop/nongrazed areas. » More

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Add DuPont™ Affinity® herbicide to your favorite wild oat or kochia program to manage Canada thistle, Russian thistle, lambsquarters, mayweed chamomile (dogfennel), wild buckwheat and other tough weeds that your program misses. » More

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DuPont™ Alkanol® XC a sodium alkyl-Naphthalene sulfonate, is a powder form surfactant whose primary uses are for wetting, rewetting and dispersing. » More

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For selective postemergence broadleaf weed control in winter and spring crops of wheat and barley, fallow, pastures, and rangeland. » More

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A 5 percent stabilized chlorine dioxide solution. » More

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Exhibit 3
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Appeel® lidding resins
Resins used as a seal layer in flexible lidding and labels. » More

Aqua-EC® coating
Coating used over plastic substrates to improve adhesion of primers and topcoats. » More

Aracon® metal clad fibers
Aramid fibers clad with a variety of metals, resulting in strong, light composite conductors and shielding materials. » More

Artistri™ digital textile printing
DuPont™ Artistri™ Technology for digital textile printing systems creates beautiful textiles for a wide variety of applications included home furnishings, apparel, gaming, flag and banner, soft signage, point of purchase and trade show displays. » More

Asana® insecticide
Controls a wide range of insect pests on field, vegetable, tree fruit, and nut crops. » More

Assure® herbicide
Provides postemergence control of both annual and perennial grasses in canola, crambe, cotton, dry beans, dry and succulent peas, lentils, mint (spearmint and peppermint), snap beans, soybeans, sugarbeets, and noncrop areas. » More

Autograph® non-stick coating for cookware
The coatings found on cookware with DuPont™ Autograph® non-stick are the absolute top of the line in their protective qualities and durability. » More

Avaunt® insecticide
Provides broad-spectrum control to protect beneficials and fruit with a short re-entry interval and also provides residual control of major worm pests. » More

Avitex® fiber softener
DuPont™ Avitex® E is a cationic hydrocarbon surfactant (Compounded Quaternary Ammonium Salt) developed to reduce static build-up on synthetic fibers. » More

DuPont™ Active Layer waterproof, breathable film
DuPont™ Active Layer is a waterproof, breathable fi lm that enhances comfort and increases value when used as a component of apparel and other textile products. It prevents external moisture and wind from penetrating through the fabric while allowing excess moisture to escape from the inside. Applications range from outdoor apparel, home furnishing, to healthcare protective garments. » More

DuPont™ Air Filters
DuPont™ filters are engineered with the latest in filter media technology to trap even microscopic particles that may affect indoor air quality. » More

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Exhibit 3
page 2 of 3

ELEMENTARY CLASSICAL PHYSICS

VOLUME I

(MECHANICS, KINETIC THEORY, THERMODYNAMICS)

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Exhibit 4
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(a) We add up the heats supplied according to the following table.

Process	*Heat supplied*
Ice, $-20°$ C to $0°$ C	$cm\,\Delta t = (0.50\ \text{cal/gm-C°})(20\ \text{gm})(20\ \text{C°}) = 0.2\ \text{kcal}$
Ice to water at $0°$ C	$mL_f = (20\ \text{gm})(80\ \text{cal/gm}) = 1.6\ \text{kcal}$
Water, $0°$ C to $100°$ C	$cm\,\Delta t = (1.00\ \text{cal/gm-C°})(20\ \text{gm})(100\ \text{C°}) = 2.0\ \text{kcal}$
Water to water vapor at $100°$ C	$mL_v = (20\ \text{gm})(539\ \text{cal/gm}) = 10.8\ \text{kcal}$
	Total $\Delta Q = 14.6$ kcal

(b) The total thermal energy supplied is *not* equal to the total increase in internal energy. This is so because, from the first law of thermodynamics, $\Delta Q = \Delta U + \Delta W$. Thus, part of the heat ΔQ supplied does not change ΔU, but manifests itself as work done on its surroundings by the expanding substance. The work done when ice is heated and melted, and when water is heated to $100°$ C, is negligible, inasmuch as the volume changes are small here. On the other hand, from the liquid ($1.0\ \text{gm/cm}^3$) to the gaseous ($6.0 \times 10^{-4}\ \text{gm/cm}^3$) state the volume change is ΔV, which is

$$\Delta V = \frac{20\ \text{gm}}{(6.0 \times 10^{-4}\ \text{gm/cm}^3)} - \frac{20\ \text{gm}}{(1.0\ \text{gm/cm}^3)}$$
$$= 3.33 \times 10^4\ \text{cm}^3 - 20\ \text{cm}^3 \doteq 33.3\ \text{liters}$$

The work done ΔW then is

$$\Delta W = p\,\Delta V = (1\ \text{atm})(33.3\ \text{l}) = 33.3\ \text{l-atm}$$

We can easily convert this energy into kilocalories by using the fact that $R = 1.99 \times 10^{-3}\ \text{kcal/mole-K°} = 0.082\ \text{l-atm/mole-K°}$:

$$\Delta W = (33.3\ \text{l-atm})\left(\frac{1.99 \times 10^{-3}\ \text{kcal/mole-K°}}{0.082\ \text{l-atm/mole-K°}}\right) = 0.8\ \text{kcal}$$

Therefore, the internal energy increase ΔU is

$$\Delta U = \Delta Q - \Delta W = (14.6 - 0.8)\ \text{kcal} = 13.8\ \text{kcal}$$

23-6 Thermal conduction

Heat is that energy-transfer process which takes place by virtue of a temperature difference. When a hot body is in contact with a cold body, thermal energy flows from the hot to the cold body. Such a flow can take place within a single body: thermal energy will flow from one region of a body at a high temperature to an adjoining region of the same body at a lower temperature, if the temperature difference is maintained between the two points. This thermal-energy transfer (often termed, redundantly, a "heat transfer process") is *thermal conduction*.

The thermal energy of a solid consists mostly of the vibration of the atoms about their equilibrium positions and, to a lesser extent, of the motion (at room temperature) of "free" electrons throughout the material. By "the atom" is here meant the nucleus together with the tightly bound electrons

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Exhibit 4
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llowing table.
lied
;m)(20 C°) = 0.2 kcal
1.6 kcal
;m)(100 C°) = 2.0 kcal
= 10.8 kcal

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that surround it. Adjoining atoms in a solid interact. Therefore, as one atom oscillates, it influences the motion of a neighboring atom. Thermal energy can be thus transferred from one atomic oscillator to another. If one region of a solid is at a higher temperature than an adjoining region, the amplitudes (and energies) of the atomic oscillations are greater at the hot regions. Thermal energy is then transferred from the hot to the cold regions by the coupling between neighboring oscillators.

If, in addition to vibrating atoms, a solid also has free electrons, as in the case of metals, these free electrons also contribute to the thermal conduction. That the free electrons play a significant role in thermal conductivity is shown by the fact that good thermal conductors, such as metals, are usually

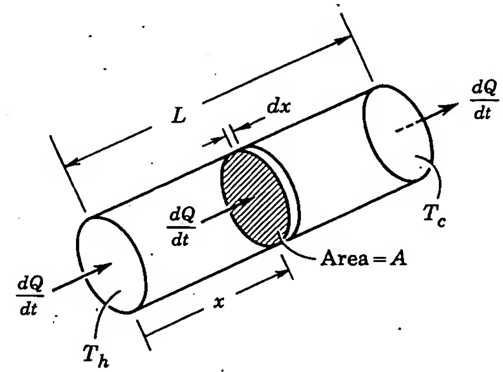

Figure 23-6. Thermal conduction through a rod of length L and cross section A, having its left and right ends at the constant *h*ot and *c*old temperatures T_h and T_c, respectively. The rate of heat through any cross section is dQ/dt.

also good electrical conductors. The free electrons are the electric-charge carriers whose transport through a material is the origin of electric currents; if the electrons are indeed free, or nearly free, they may then act to transfer thermal energy as well as electric charge.

We now turn to the quantitative aspects of thermal conduction. Consider the situation shown in Figure 23-6. Here a rod of uniform cross section A is surrounded by an insulating material, so that no heat leaks into or out of the rod through its sides. The *h*ot left end is maintained at a constant high temperature T_h while the *c*old right end is maintained at a constant lower temperature T_c. The thermal energy entering the rod per unit time from the hot reservoir (that is, the heat rate into the rod) is dQ/dt. This is also the heat per unit time leaving the right end. In fact, dQ/dt represents the thermal energy crossing the area A per unit time at *any* point along the rod. The

net heat entering the rod, or entering any small volume of the rod, is *zero*; therefore, the internal energy of the rod remains *constant*. The rod, a thermal conductor, acts merely as a "heat pipe" between the hot and cold reservoirs, degrading thermal energy by sending it to a lower temperature. This behavior continues, of course, only as long as the two ends are maintained at T_h and T_c. When $T_h = T_c$, then $dQ/dt = 0$.

How does the temperature vary along the length of the uniform rod? Measurements show that the temperature drops *uniformly* from the hot to the cold end. The temperature *at any one point* along the rod is unchanged as long as the ends are maintained at constant temperatures.

To obtain the general expression describing thermal conduction, let us concentrate on the temperatue drop dT occurring across a thin section of thickness dx. The quantity dT/dx, called the *temperature gradient*, measures the temperature change per unit displacement along the direction of heat flow. If x is taken as increasing along the direction of dQ/dt, the temperature gradient dT/dx is *negative*; that is, the temperature *drops* as x increases.

Experiment shows that the heat rate $R \equiv dQ/dt$ is related to the temperature gradient dT/dx by

$$\boxed{R = dQ/dt = -KA\ dT/dx} \qquad [23\text{-}7]$$

where A is the cross-sectional area through which the thermal energy flows. The quantity K is a positive constant, called the *thermal conductivity*. It is characteristic of the material of the thermal conductor. Equation 23-7 then shows that, for a slice of infinitesimal thickness, the heat rate varies directly as the cross-sectional area and the temperature gradient.

When we integrate Equation 23-7 over the entire rod of length L, extending from $x = 0$ to $x = L$, with the corresponding temperatures T_h and T_c, respectively, we find

$$R = -KA\ dT/dx$$

$$R\int_0^L dx = -KA\int_{T_h}^{T_c} dT$$

Note that R, K, and A are all constants. Then,

$$R = \frac{dQ}{dt} = \frac{KA(T_h - T_c)}{L} \qquad [23\text{-}8]$$

The differential form of the thermal-conduction equation given in Equation 23-7 is more general than that given in Equation 23-8. Equation 23-7 can be applied to *all* shapes of conductors, not merely to uniform rods. (One

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Exhibit 4
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[23-8]

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can imagine the conductor to consist of a collection of infinitesimally thin sheets for each of which the differential form holds exactly.)

Measured values of the thermal conductivity K for various materials are given in Table 23-3. A good thermal conductor has a high value of K; a

Table 23-3

SUBSTANCE	TEMP. (°C)	THERMAL CONDUCT. (kcal-m/sec-m²-C°)
Conducting		
Aluminum	−190 to 30	0.050
Copper	−160	0.108
Copper	18	0.092
Copper	100	0.091
Silver	18	0.101
Lead	18	0.0083
Water	20	0.0014
Insulating		
Concrete		0.0002
Cork		0.00001
Glass, wool	50	0.00001
Ice	0	0.0005
Air	0	0.000006

low value of K characterizes a poor thermal conductor, or a good insulator. The units assigned to K depend upon the units used for dQ/dt, $T_h - T_c$, A, and L. For example, if dQ/dt is in kilocalories per second, $T_h - T_c$ in Celsius degrees, A in square meters, and L in meters, then the units for K must be given as (kcal/sec)(m)/m²-C°, to be in accord with Equation 23-8. Still other units, of course, are possible. In engineering practice it is common to give dQ/dt in British thermal units per second, $T_h - T_c$ in Fahrenheit degrees, A in square feet, and L in inches; then the thermal conductivity is written with the units (BTU/sec)(inch)/feet²-F°.

Example 4 An electric heater operating at 200 watts is placed in the interior of a cubical box constructed of insulating material. See Figure 23-7. The edge length of the box is 20 cm and the thickness of each side is 1.0 cm. After the heater has been on for a sufficiently long time, dynamic thermal equilibrium is achieved; the interior surfaces of the box remain at the constant temperature 60° C while the exterior surfaces are at the temperature 20° C. (a) What is the rate of thermal-energy flow out of the box? (b) What is the thermal conductivity of the material of which the box is constructed?

(a) The thermal energy from the electric heater passing into the walls of the box must equal the thermal

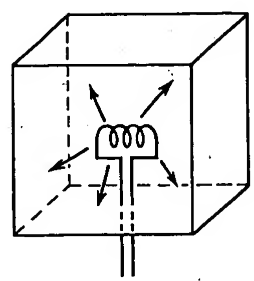

Figure 23-7. An electric heater inside an insulating box.

energy leaving the box. Thus, the rate of thermal-energy flow *out* of the box is

$$dQ/dt = 200 \text{ watts} = (200 \text{ watts})\left(\frac{1 \text{ joule/sec}}{1 \text{ watt}}\right)\left(\frac{1 \text{ cal}}{4.19 \text{ joules}}\right)\left(\frac{1 \text{ kcal}}{10^3 \text{ cal}}\right)$$
$$= 0.048 \text{ kcal/sec}$$

(b) The total area A can be taken as the area of one side, $(0.20 \text{ m})^2$, multiplied by the number of sides (6) of the cube. The thickness L is 0.010 m. Since the edge length of a side is large compared with the thickness of a side, we may properly neglect heat flow along the edges. Thus, Equation 23-8 gives

$$K = \frac{(dQ/dt)L}{A(T_h - T_c)} = \frac{(0.048 \text{ kcal/sec})(0.010 \text{ m})}{6(0.20 \text{ m})^2(40 \text{ C}°)} = 5.0 \times 10^{-5} \text{ (kcal/sec)(m/m}^2\text{-C}°)$$

Good thermal insulators, such as asbestos, have thermal conductivities of this order.

23-7 Convection In thermal conduction, energy is transferred from particle to particle, not because a particle moves through the material but because the atoms are coupled together. The atoms of a fluid (a liquid or gas) do not, however, have to remain localized in position; they can move throughout the material. As a consequence, another thermal-energy transfer process, known as *convection*, can take place.

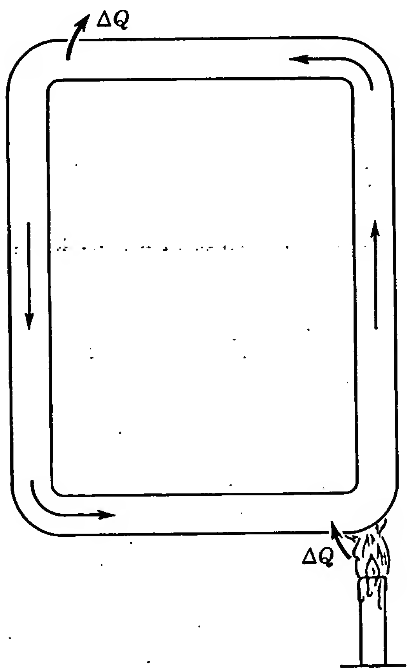

Figure 23-8. Thermal-energy transfer by convection.

The essential features of convection are shown in Figure 23-8. Here a liquid, held in a closed pipe, is heated at the lower point shown. Assume that the liquid has a positive coefficient of thermal expansion; that is, the density of the liquid decreases with a rise in temperature. Then, as the liquid is heated, its density will be reduced, and it will rise in the pipe. Thermal energy is transferred out of the liquid by conduction at an upper section of the pipe. The temperature of the liquid will then decrease, the liquid's density will increase, and the liquid will readily descend through the return pipe to its starting point. Therefore, in convection, energy is transported from one point in space to another by the bulk displacement of a material.

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$$\frac{\Delta Q}{\Delta t} = \frac{A(T_2 - T_1)}{(L/K)}$$

A = Area = constant

$(T_2 - T_1)$ = Temperature differential

L = constant $X = A(T_2 - T_1)$

X = constants

(1) For only one component

$$\frac{\Delta Q}{\Delta t} = \left(\frac{X}{L}\right) K$$

(2) For two components (each at 50% by volume) means $L = \frac{L}{2}$ for each since area is constant

$$\frac{\Delta Q}{\Delta t} = \frac{X}{\left(\left(\frac{L}{2K_1}\right) + \left(\frac{L}{2K_2}\right)\right)}$$

$$\frac{\Delta Q}{\Delta t} = \left(\frac{X}{L}\right) \frac{1}{\left(\frac{1}{2K_1} + \frac{1}{2K_2}\right)} = \left(\frac{X}{L}\right) \frac{1}{1/2\left(\frac{K_1 + K_2}{K_1 K_2}\right)}$$

$$\frac{\Delta Q}{\Delta t} = \left(\frac{X}{L}\right)\left(\frac{2K_1 K_2}{K_1 + K_2}\right)$$

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(3) For two components (one at 25% and the other at 75%) means $L = L/4$ for the 25% component $L = 3L/4$ for the 75% component

$$\frac{\Delta Q}{\Delta t} = \frac{X}{\left(\frac{L}{4K_1} + \frac{3L}{4K_2}\right)}$$

Exhibit 5
page 1 of 4

$$\frac{\Delta Q}{\Delta t} = \left(\frac{X}{L}\right) \frac{1}{1/4\left(\frac{1}{K_1} + \frac{3}{K_2}\right)} = \left(\frac{X}{L}\right) \frac{1}{1/4\left(\frac{K_2 + 3K_1}{K_1 K_2}\right)}$$

$$\frac{\Delta Q}{\Delta t} = \left(\frac{X}{L}\right)\left(\frac{4K_1K_2}{K_2+3K_1}\right)$$

Calculations $K_{water} = 1.4 \times 10^{-3} = 140 \times 10^{-5}$

$K_{glasswool} = 1.0 \times 10^{-5}$

1 <u>One component water</u>

$$\frac{\Delta Q}{\Delta t} = \left(\frac{X}{L}\right) 140 \times 10^{-5}$$

<u>One component glass wool</u>

$$\frac{\Delta Q}{\Delta t} = \left(\frac{X}{L}\right) 1.0 \times 10^{-5}$$

Ratio: $$\frac{\frac{\Delta Q}{\Delta t}\text{ water}}{\frac{\Delta Q}{\Delta t}\text{ glasswool}} = \frac{\left(\frac{X}{L}\right) 1.40 \times 10^{-5}}{\left(\frac{X}{L}\right) 1.0 \times 10^{-5}} = 140$$

2 <u>Two components</u> 50% by volume glass wool
50% by volume water

$$\frac{\Delta Q}{\Delta t} = \left(\frac{X}{L}\right) \frac{(2)(140\times10^{-5})(1\times10^{-5})}{(140\times10^{-5}+1\times10^{-5})} = \left(\frac{X}{L}\right) 1.99\times10^{-5}$$

Ratio:

$$\frac{\frac{\Delta Q}{\Delta t}\ \text{water}}{\frac{\Delta Q}{\Delta t}\ \substack{50/50\\ w/gw}} = \frac{\left(\frac{X}{L}\right) 140\times10^{-5}}{\left(\frac{X}{L}\right) 1.99\times10^{-5}} = 70.5 \sim 71$$

<u>Two components</u> 25% by volume glass wool
75% by volume water

$$\frac{\Delta Q}{\Delta t} = \left(\frac{X}{L}\right) \frac{(4)(1.0\times10^{-5})(140\times10^{-5})}{140\times10^{-5}+3(1.0\times10^{-5})} = \left(\frac{X}{L}\right) 3.92\times10^{-5}$$

Ratio:

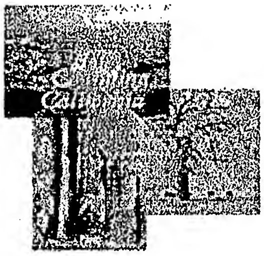
$$\frac{\frac{\Delta Q}{\Delta t}\ \text{water}}{\frac{\Delta Q}{\Delta t}\ \substack{25/75\\ gw/w}} \quad \frac{\left(\frac{X}{L}\right) 140\times10^{-5}}{\left(\frac{X}{L}\right) 3.92\times10^{-5}} = 35.75 \sim 36$$

<u>Two components</u> 75% by volume glass wool
25% by volume water

$$\frac{\Delta Q}{\Delta t} = \left(\frac{X}{L}\right) \frac{(4)(140\times10^{-5})(1.0\times10^{-5})}{\left((3)(140\times10^{-5}) + 1.0\times10^{-5}\right)} = \left(\frac{X}{L}\right) 1.33\times10^{-5}$$

Ratio:

$$\frac{\left(\frac{\Delta Q}{\Delta t}\right)_{\text{water}}}{\left(\frac{\Delta Q}{\Delta t}\right)_{75/25\ \text{gw/w}}} = \frac{\left(\frac{X}{L}\right) 140\times10^{-5}}{\left(\frac{X}{L}\right) 1.33\times10^{-5}} = 105.25 \sim 105$$



The Changing California
Forest and Range 2003 Assessment

Synopsis

Related Information
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Wildfire Risks to Assets

Wildfire Risks to Assets

Wildfire Risks to Assets (pages 1-8) (4,789 KB)

Wildfire Risks to Assets (pages 9-22) (5,904 KB)

October 2003

On average, wildfires burn a quarter million acres of forest and rangeland annually in California. While most terrestrial ecosystems in California have evolved over millennia with fire as an integral process, current conditions in many areas make fire potentially damaging to natural, social, and economic resources important to the people of the State. This chapter focuses on how wildland fire poses risk to five key assets: 1) people and property in developed areas; 2) ecosystem health; 3) timberlands; 4) range forage; and 5) soils.

Photo courtesy of the Bureau of Land Management.

- Risk from wildfire is specific to the asset or resource under concern. A particular fire event that is damaging to one resource may actually be beneficial to another.
- Risk from fire is driven by two principal characteristics of the fire event—its expected frequency, and its expected fire behavior. The Fire and Resource Assessment Program combined these two components into a single metric called "Fire Threat".

Fire risks to people and property

- A significant risk from fire is posed to the people and houses in California, as more structures are built in areas with a significant wildland Fire Threat.
- A total of 7.8 million acres of California are developed with housing unit densities considered to meet the Wildland-Urban Interface (WUI) criteria. Of this total, 920,000 acres (12 percent) are exposed to an Extreme Fire Threat, 3.4 million acres (43 percent) to a Very High threat, and an additional 1.2 million acres (15 percent) to a High threat. If we consider all WUI lands with threat levels greater than Moderate to be at significant risk to damage from fire, the total area is 5.5 million acres, or 70 percent of the total WUI area.

Area of wildland urban interface by density class and percentage area by fire threat, 2000

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Density class	Acres	Extreme (%)	Very High (%)	High (%)	Moderate (%)	None (%)

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Rural	3,126,844	15	55	13	15	2
Interface	1,322,621	19	55	13	12	1
Urban	3,391,217	6	27	18	47	2
Total	7,840,682	12	43	15	29	1

- A total of 11.8 million homes are located in the WUI. Of this, 4.9 million housing units (42 percent) are exposed to High or greater Fire Threat. Furthermore, of these, 4.1 million homes (84 percent) are from urban areas, where density of housing units exceeds one unit. Thus while the land area considered WUI is dominated by areas of relatively low development density, the majority of houses at risk come from urbanized areas.

Number of housing units in the wildland urban interface by density class and percentage of housing units in the wildland urban interface by fire threat, 2000

Density class	Total houses	Extreme (%)	Very High (%)	High (%)	Moderate (%)	None (%)	All threats (%)
Rural	323,284	<1	2	<1	<1	<1	3
Interface	597,498	1	3	1	1	<1	6
Urban	10,886,540	3	18	14	56	1	91
Total	11,807,323	4	23	15	57	1	100

Significant Fire Risk to housing units in WUI = housing units in WUI in Extreme, Very High and High Fire Threat classes
<1 = less than 1 percent

- An additional 8.6 million acres of wildlands surrounding WUI communities pose Very High or Extreme Fire Threat conditions. These lands represent many of the areas requiring mitigation treatments to reduce risks to people and property of the State.

Fire risks to ecosystem health

Wildfire can cause serious and long-lasting damage to ecosystems. Condition Classes have been developed that relate current ecosystem conditions and expected fire effects relative to how these systems were affected by historic fire regimes. These classes are assigned based on current vegetation type and structure, expected fire frequency, and potential fire behavior. Fundamental to the assignment of Condition Class measures is the concept of natural fire regime and current fire conditions.

- A total of roughly 37 million acres are ecologically at risk from fire with 17 million acres of these at high risk. These lands span diverse ecosystems ranging from pine forests in the Klamath/North Coast region to coastal sage scrub communities along the South Coast. Numerous areas of the State are dominated by ecosystems at risk from wildfire.
- The Modoc and other forested regions of the Klamath/North Coast and Sierras are at ecological risk due to unnaturally severe fires. The sagebrush steppe that dominates portions of California's Modoc region lands has largely lost its basic ecological integrity and demonstrates the pervasive influence of alien exotic grasses. Future fires only exacerbate this problem.

Percentage area of forests and rangelands in Condition Class 2 and 3 (Moderate and High)

Bioregion	Percentage
Bay Area/Delta	42
Central Coast	51
Colorado Desert	5
Klamath/North Coast	68
Modoc	86
Mojave	6
Sacramento Valley	29
San Joaquin Valley	13
Sierra	68
South Coast	70

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Fire risks to range forage, timber, and soil erosion

- Range forage is an important economic resource to the ranchers of California. Fire can impose significant, short-term losses of forage when standing crops are consumed by fire. Of the $138 million dollars of value ascribed to rangeland forage annually, a total of $2.5 million is estimated to be lost due to wildfire.
- Timber assets and key woodland habitats are both at risk from fire. Roughly three quarters of California's timberlands and two-thirds of its woodlands are in conditions that support High to Extreme Fire Threat.
- Fire can trigger significant surface soil erosion. This can result in loss of site productivity, degradation of stream habitats, and damage to social infrastructure. Roughly 29 million acres of California is estimated to support High or Very High levels of surface erosion following wildfire. An additional 34 million acres are estimated to support Moderate levels of surface erosion.

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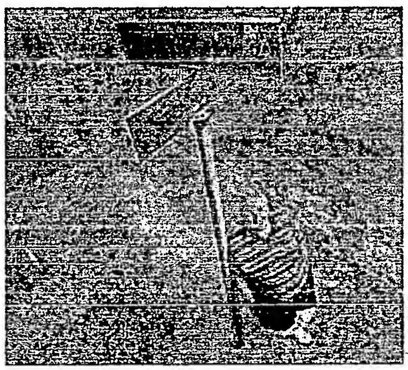
Risk doesn't deter growth in fire-prone areas

By John Ritter, USA TODAY

VALLEY CENTER, Calif. — Lawrence Williams peers across Hell Hole Canyon, cooked black by fire that raced through here like a runaway train, and marvels that his dream house still stands.



John Charles Jr. has lived for 5 years in the Valley Center area. He was forced to evacuate the area during the Paradise Fire in Oct 2003.

By Dan MacMedan, USA TODAY

Had flames torched it like so many other Southern California homes, Williams would have wasted no time rebuilding. He won't leave his pristine hilltop in exurbia and its views of the moon over Santa Catalina Island off the Pacific coast 100 miles away. (**Related audio:** Lawrence Williams talks about surviving last summer's fires in Southern California)

A precision tool mechanic, Williams commutes an hour to San Diego but comes home to a place where coyotes outnumber neighbors, where black nights reveal impossibly bright stars and a cloudy wisp that is the Milky Way city dwellers never see.

"Out here away from people, we feel more secure, silly as that sounds," says Williams, 40. "There's not much crime."

Williams' country living falls within what foresters call the "wildland-urban interface," open land beyond the bustle but susceptible to one of nature's most destructive forces — wildfires.

Blazes that torched 760,000 acres in San Diego and four other Southern California counties last fall claimed 25 lives and more than 3,600 homes. Property damage topped $3.5 billion. For days, the nation was transfixed by TV images of towering, wind-driven flames, smoke-choked landscapes, whole neighborhoods leveled to smoldering rubble and thousands of distraught homeowners forced into shelters fearing the worst.

Bad as it was, the disaster won't slow migration into fire-prone areas, demographers say. It will take more than the worst fire disaster in California history to douse a decades-long trend.

Growth pressure will worsen an alarming fire risk in the West, experts say. Whether it's driven by the tug of nature, hope for affordable housing, the dream of a vacation home or a yen to leave congestion behind, suburban sprawl to the metropolitan fringe will increasingly encroach on wildlands.

Outside California, population has grown rapidly in the nation's other high-risk region, the eight Rocky Mountain states — particularly around Denver, in the Bitterroot Valley in western Montana and parts of Arizona, New Mexico,

Utah and Idaho.

Fires often plague Florida, too, but woodlands elsewhere in the USA pose less risk than the West because of wetter climates, effective programs to thin vegetation or a prevalence of hardwood species that rarely burns. Those areas include the rural lands around greater Atlanta, the pine forests of the Carolinas, central Michigan's jack-pine woods, New Jersey's Pine Barrens and the heavily wooded Pacific Northwest.

Nowhere are the stakes higher than in the nation's most populous state, where a Mediterranean climate's wet winters and warm, dry summers make fire seasonal and habitual. "California has been fire central forever," says Greg Aplet, senior forest scientist with the Wilderness Society. The state forestry department says 7.2 million homes — more than half the state's total — are vulnerable to wildfire.

Flirting with danger

Blazes that for millenniums have ridden fierce winds through California's hills and canyons can't be prevented. But neither can the advance of people into risky zones.

Last fall's "perfect storm" scenario could repeat: A string of fast-growing supersuburbs ablaze in an arc ringing urban Southern California from Simi Valley west of Los Angeles to Fontana in the east and south to Escondido outside San Diego. All have been among the USA's fastest growing "boomburbs" for 20 years.

At the rate it's growing, California will add 15 million people in the next 30 years, dwarfing any other state's growth. Most of the new population will settle in cities and suburbs, but hundreds of thousands will push into exurbia.

If California and the Rockies are the locus of the nation's fire threat, the two regions have starkly different approaches to easing dangers.

In more densely populated California, wildfires have been a public policy priority for decades. In the 1960s, when the Rockies were still sparsely inhabited, California already was requiring homeowners to keep vegetation cleared around homes in fire-prone areas.

In 1990, roof standards, minimum road widths for firetruck turnarounds and other mandates were enacted. Many cities and counties went further with even tougher codes than the state's. Last year, the Legislature authorized the state fire marshal to devise stricter statewide building standards for wildfire zones.

But in the Rockies, fire mitigation remains almost exclusively up to homeowners. No mountain state has mandatory measures.

"I can probably count on one hand the number of counties that have even begun to take the kind of steps that California has taken," Aplet says. Notable exceptions are Jefferson and Boulder counties outside Denver.

Though fire is as common to the Rockies as California, risks have escalated only as the "Colorado experience" lured waves of newcomers. Nationally, at least 34 million people live in wildland areas that are at potential risk to fire.

Population in the eight Rocky Mountain states — Idaho, Montana, Wyoming, Utah, Colorado, Nevada, New Mexico and Arizona — jumped 42% since 1990, the Census Bureau says. Market researcher Claritas Inc. estimates the region will grow 10% more by 2008.

Those numbers don't tell the whole story. In some states, almost everybody lives on land with fire potential. While only 2% of New Mexico's land lies in such areas, 80% of the houses do, according to Forest Service data. Wyoming has the same pattern. In other Western states, including California, Washington and Oregon, 40% to 55% of houses are in such areas.

Aggravating the threat: a century of government policy bent on fighting almost every Western fire, leaving wildlands overgrown and ripe for catastrophic burns.

In the past four years, fires around Los Alamos, N.M., in the Bitterroots of Montana, in east-central Arizona, southwest of Denver and south of Tucson consumed hundreds of homes. But that was less than half the toll of three weeks in Southern California.

Insurance companies in California won't write new polices or renew coverage if homeowners in risky areas ignore fire standards. But insurers are just now following suit in the Rockies. A State Farm test program of 24,000 policyholders in six mountain states gives homeowners up to 29 months to reduce risks identified by U.S. Forest Service-trained inspectors.

Tougher regulations

With insured wildfire losses comparatively small — summer hail damage is far greater — insurers until recently had little incentive to require mitigation. But Carole Walker, executive director of the Rocky Mountain Insurance Information Association, says most companies are getting tougher.

"Droves of people are moving to the foothills," Walker says. "Same thing in New Mexico, Utah and Wyoming. This old feeling of 'I don't want to cut my trees' won't work anymore."

In the West, where zoning is a four-letter word, some doubt change is at hand. "People will fiercely defend their right not to protect themselves," Aplet says.

California's regulations and its insurance industry's insistence on fire mitigation grew in part from the state's history of costly blazes in populated areas. Since 1991, fires in the Oakland Hills, in Laguna and twice in Malibu have destroyed thousands of homes and left billions in losses. Scripps Ranch, a development where 2,200 homes burned last fall, lies within San Diego city limits.

Scripps Ranch resident Bill Mazzei, an anesthesiology professor at the University of California-San Diego, worried about earthquakes, not fire, when he bought his home 18 years ago. If his neighborhood association hadn't kept brush cleared behind his house, it might have burned like several others near him that had wood roofs.

Tile roofs, stucco walls and double-pane glass helped save thousands of homes. "I don't think people gave fire much thought," Mazzei says.

Proactive as California is, gaps remain. The state's minimum 30 feet of clearance and a class-C roof in risky areas — class-A is the most fire resistant — wouldn't have saved Matt Tisch's house from the wall of flame that rousted his family. San Diego County requires a class-A roof, usually tile or metal, 100 feet of clearance, non-combustible wall materials, a 10,000-gallon water-storage tank and interior sprinklers in most cases.

"I was worried because we had 20 years of vegetation growth behind us," says Tisch, 42, a medical contractor. "I've been at it for years, keeping a huge margin cleared."

Pete Moraga, spokesman for the Insurance Information Network of California, says he knows of no cases where homeowners were denied insurance settlements because they hadn't cleared brush.

Forcing homeowners to comply with safety measures is costly and often spotty. With thousands of homes spread over large areas, fire departments — or insurance companies — are hard-pressed to make regular inspections.

Firefighters inspected 35,151 properties in unincorporated San Diego County in 2002, barely a third of the total homes. Last year, with the burden of fighting the fires, inspections dipped to 21,885.

Tame fires become monsters

Topography and building patterns set up many communities for disaster. Homes intermingled through the county's canyons were easy prey. Wind and dry conditions turned controllable blazes into monsters.

"What happened in Southern California over the last 30 years is all the flat lands were built on," says John Landis, a city and regional planning professor at the University of California-Berkeley. "Then the crevices, the valleys,

gradually got filled up, mostly in an unplanned way without much attention to firefighting."

Landis contrasts San Bernardino County, which lost hundreds of homes, with Ventura County, which lost none. Much of San Bernardino was built "house by individual house" with little planning. But in Ventura, where most development is master-planned, "the firetrucks drive right up into the subdivisions," he says.

Fate and neighbors' diligence also weigh heavily. Sheriff's deputy Vic Perry says his house on 4 acres in Valley Center would have burned if he hadn't whacked foot-tall weeds in the back days before. But some of his neighbors lost homes because *their* neighbors left too much vegetation.

All of Valley Center, population 15,000, lies in the "wildland-urban interface." Many residents are here for that reason. On the periphery, at Paradise Mountain and Hell Hole Canyon, homeowners like Tisch back up to federal land that will never be developed. They wouldn't have it any other way.

"The payoff is huge," says Tisch, explaining why fire won't stall growth. "It's awesome. I can see mountains well into Mexico and the San Gabriels north of Pasadena. For me, it's perfect."

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